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Kenning

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(54) **MUD GUN CAP**

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Related U.S. Application Data

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(51) **Int. Cl.**
C21B 7/12 (2006.01)
F27D 3/15 (2006.01)
C21C 5/46 (2006.01)

(52) **U.S. Cl.**
CPC ***C21B 7/12*** (2013.01); ***C21C 5/4653*** (2013.01); ***F27D 3/1536*** (2013.01)

(58) **Field of Classification Search**
CPC C21B 7/12; C21B 7/125; C21C 5/4653; F27D 3/1536; F27D 3/15
See application file for complete search history.

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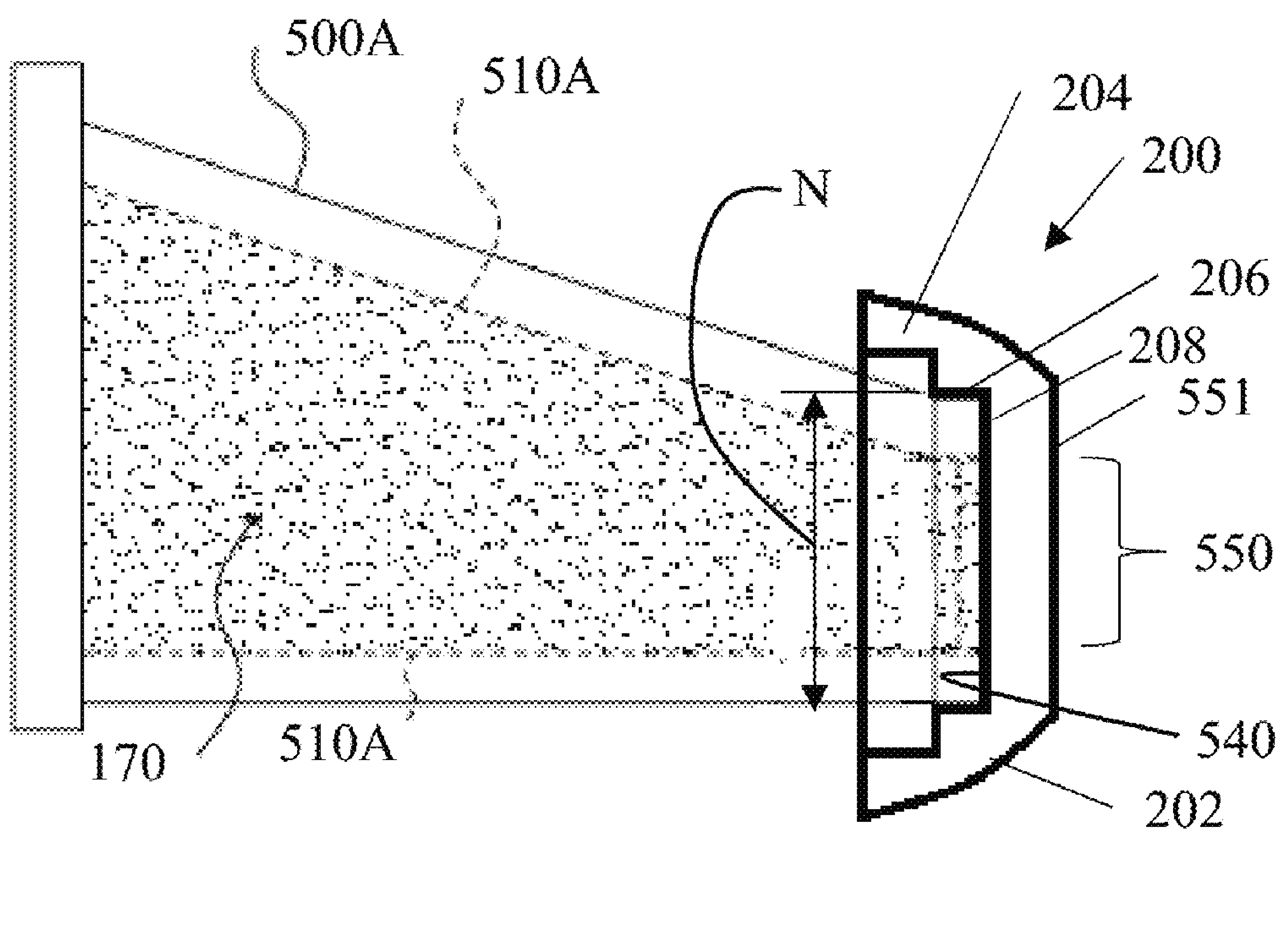
(57) **ABSTRACT**

Exemplary embodiments of mud gun caps are disclosed herein. An exemplary mud gun cap includes a flame-resistant body that has a tap hole contacting surface. The flame-resistant body has side wall; a first bore and a second bore located within the flame-resistant body. The first bore has a first diameter and second bore has a second diameter. The first diameter is smaller than the second diameter and the second bore is located farther away from the tap hole contacting surface than the first bore.

11 Claims, 7 Drawing Sheets



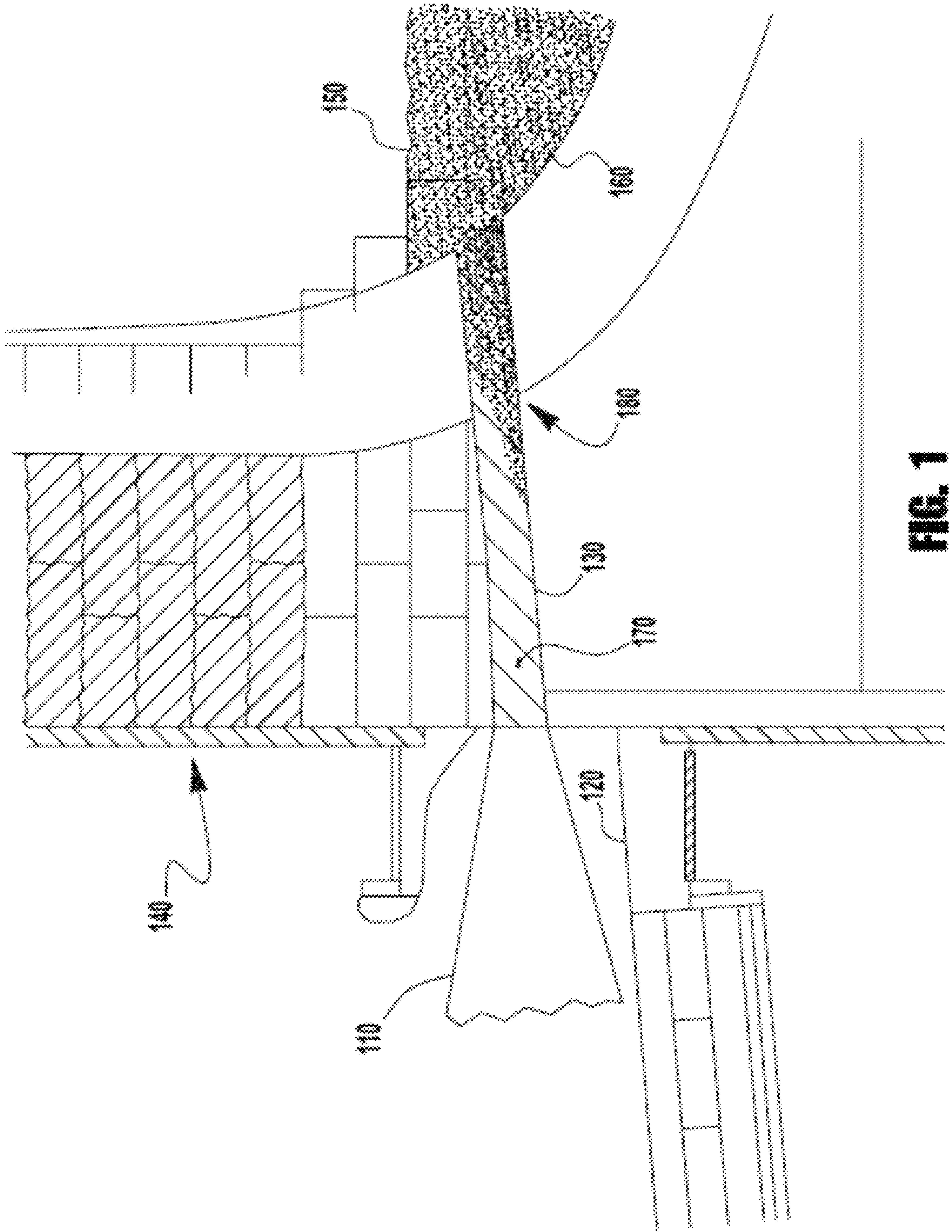


FIG. 1
PRIOR ART

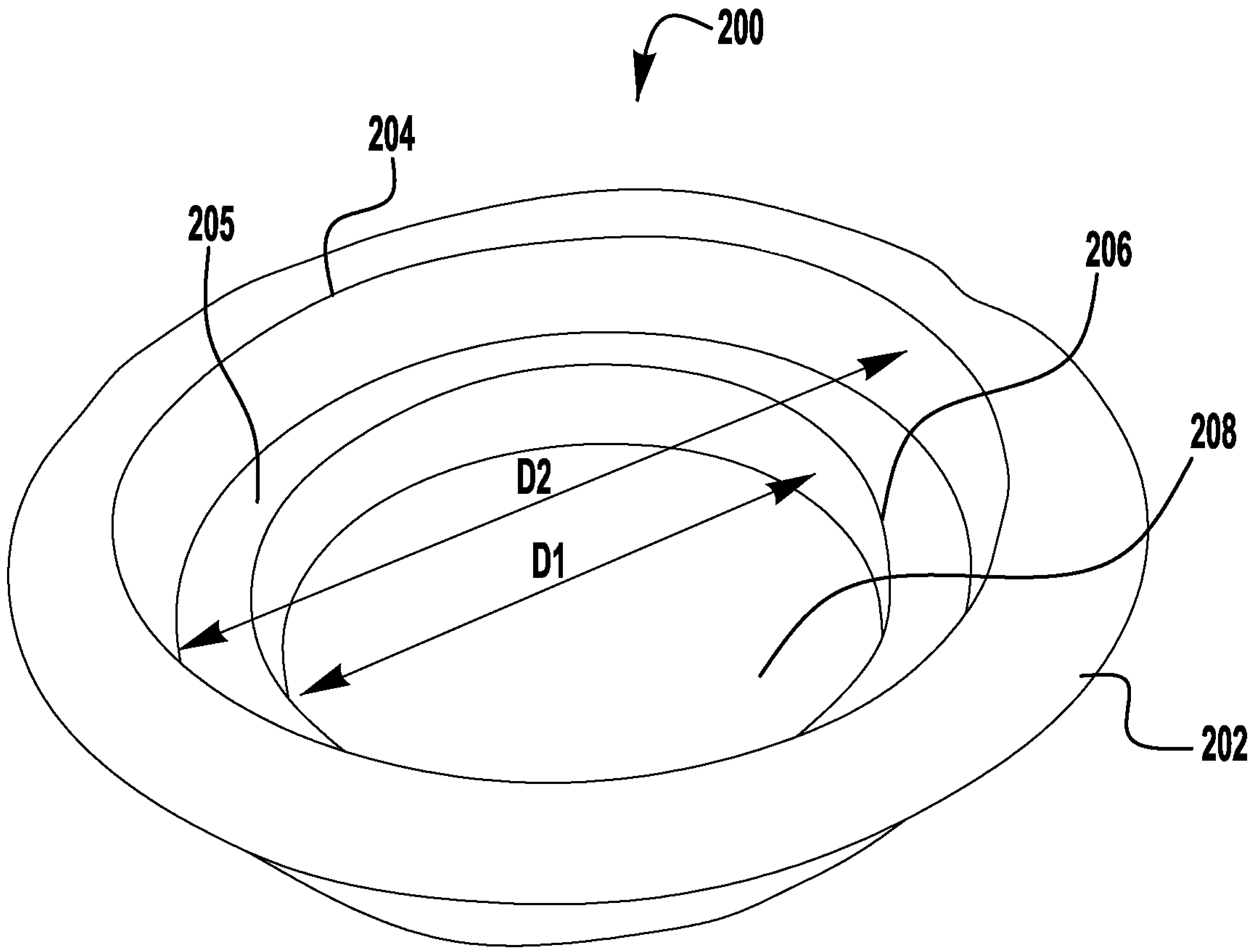


FIG. 2

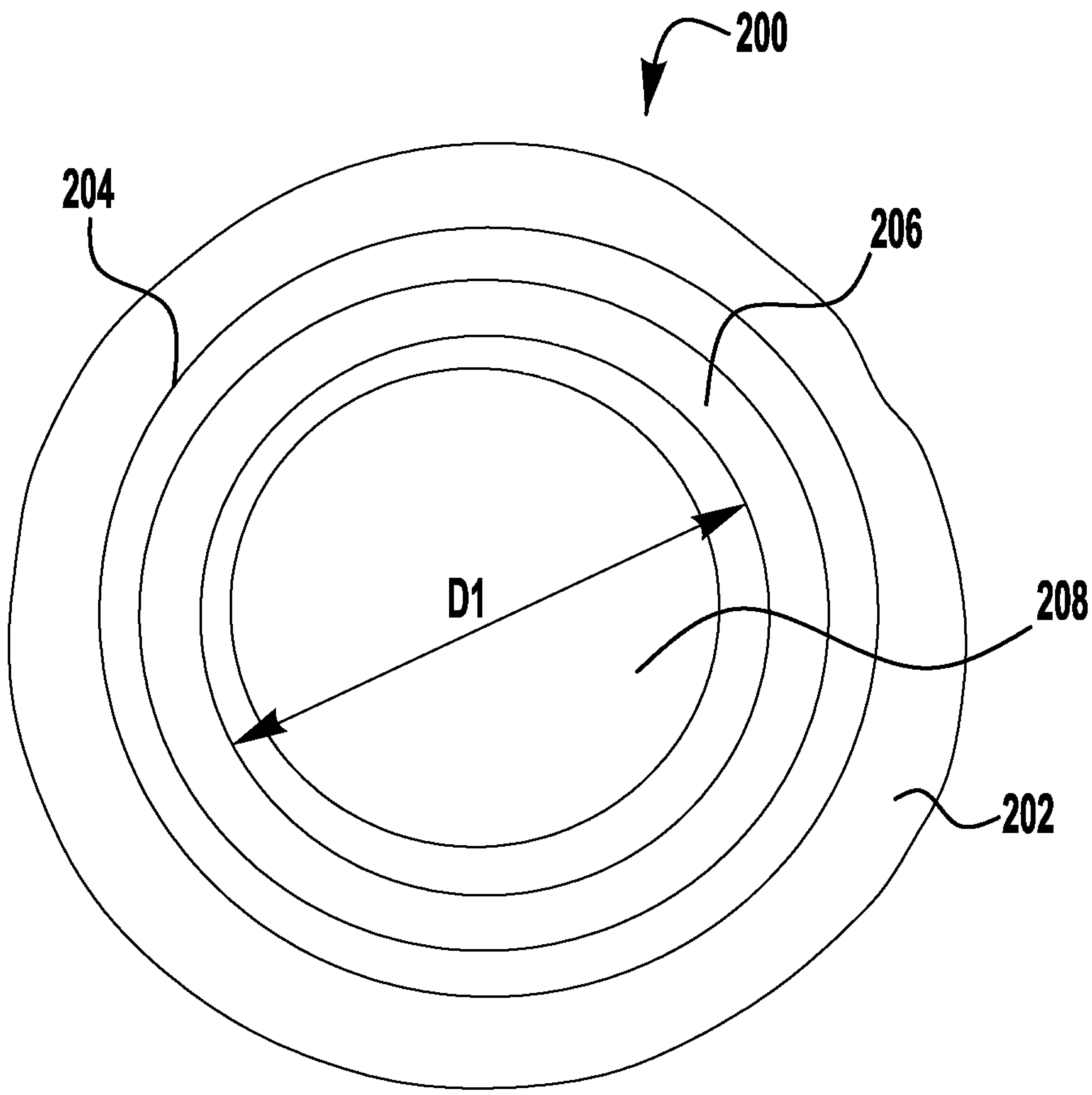


FIG. 3

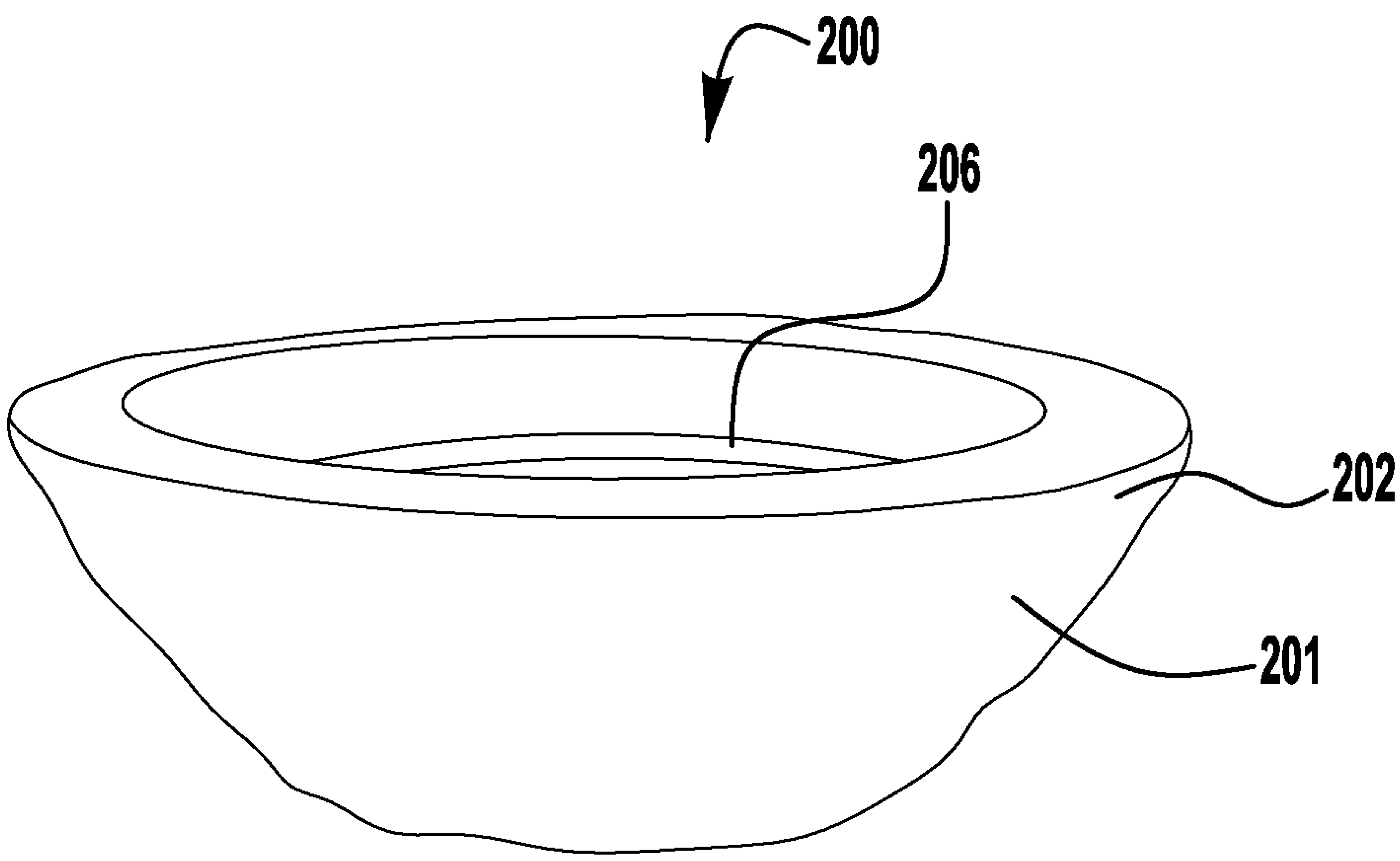


FIG. 4

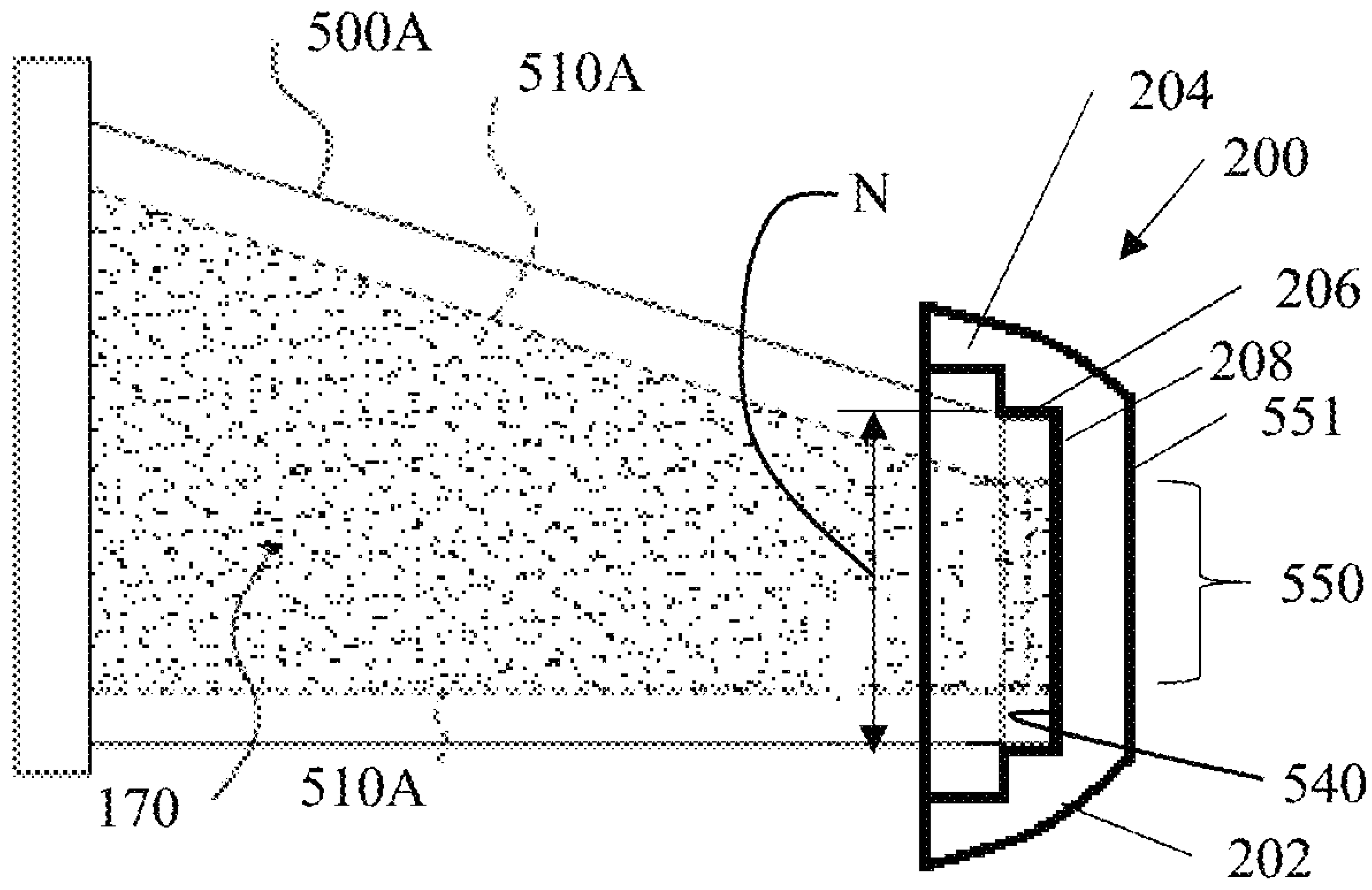

500A
510A
204
200
N
206
208
551
550
540
202
170
510A

FIG. 5A

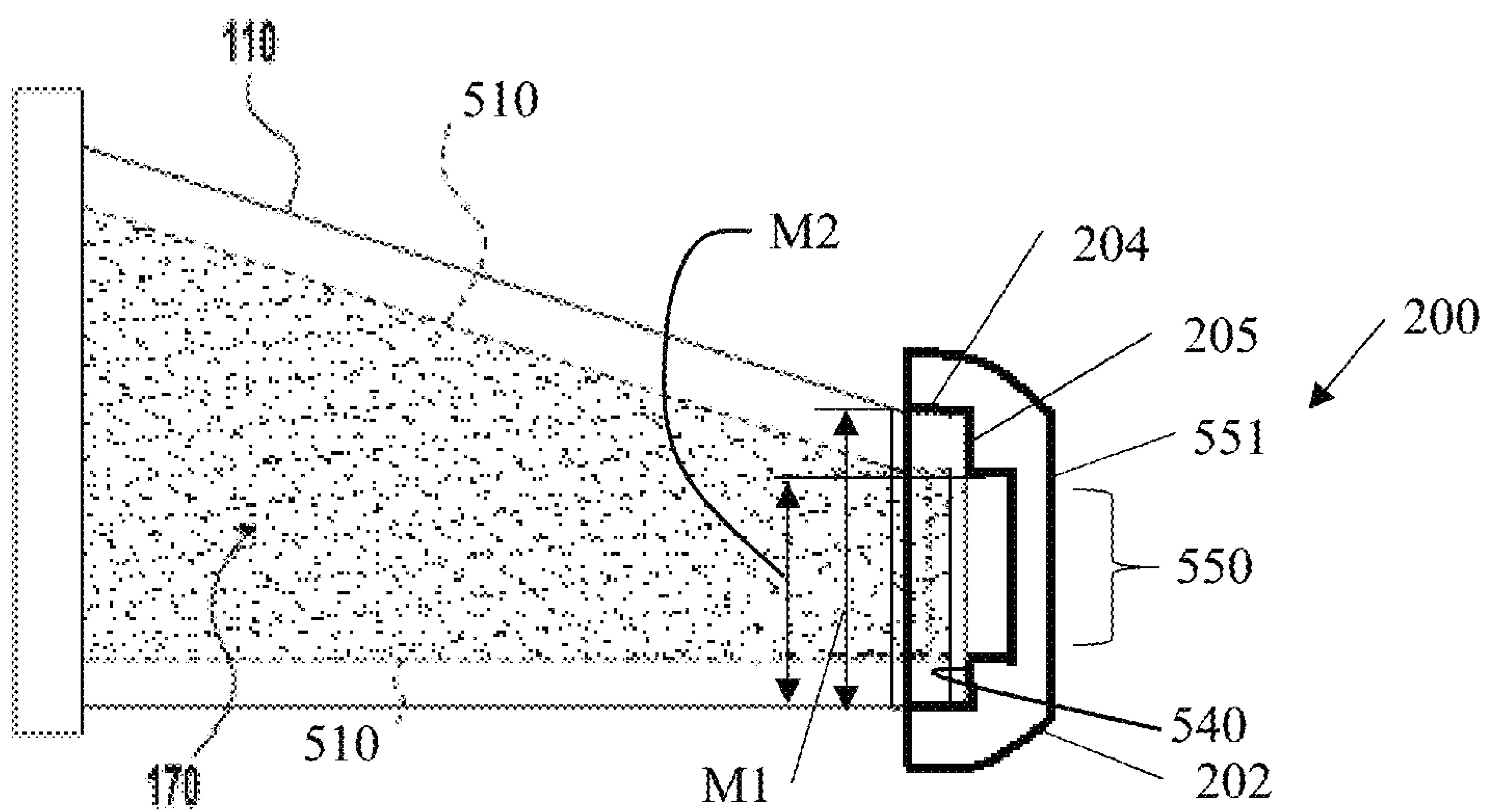

110
510
M2
204
200
205
551
550
540
202
170
510
M1

FIG. 5B

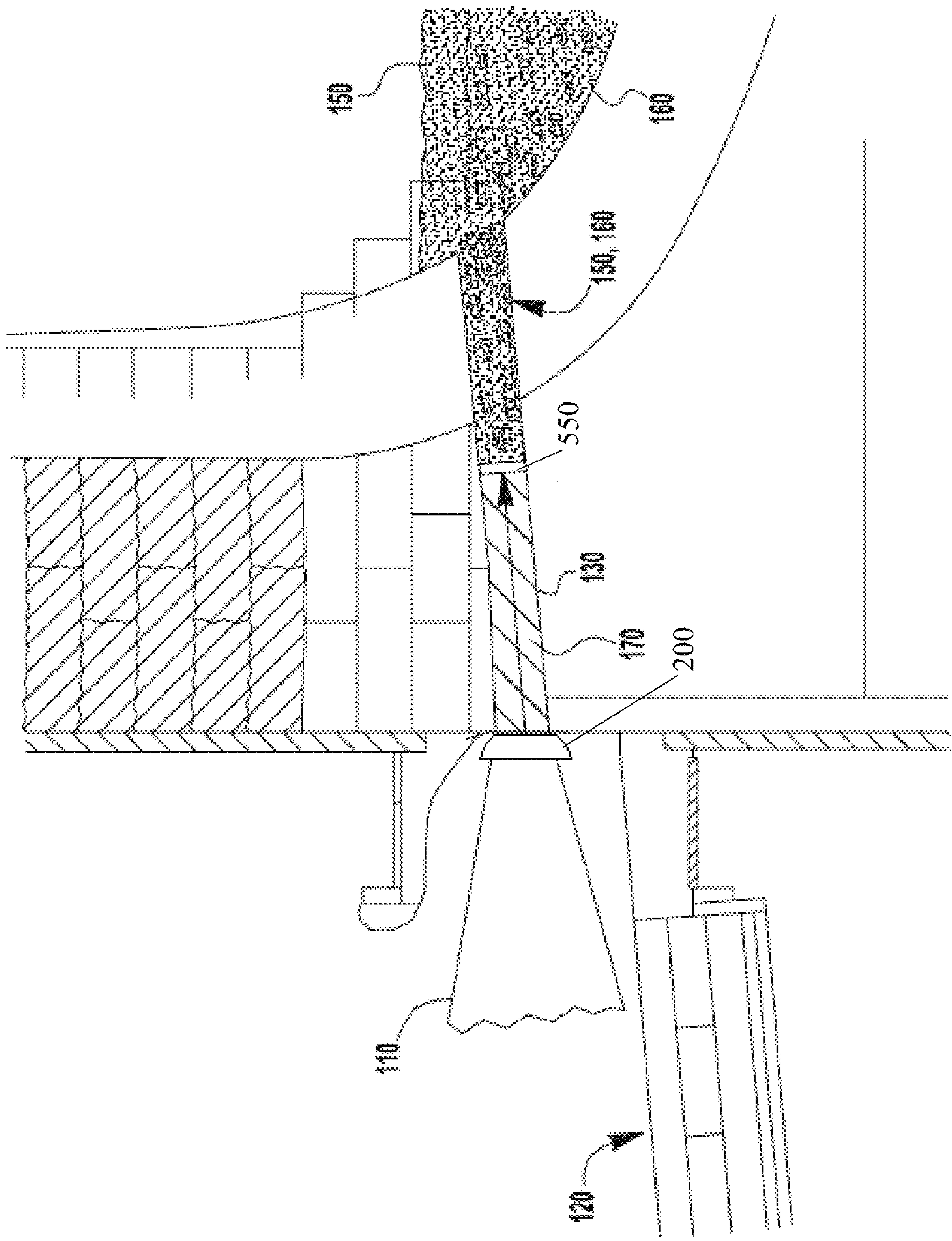


FIG. 6

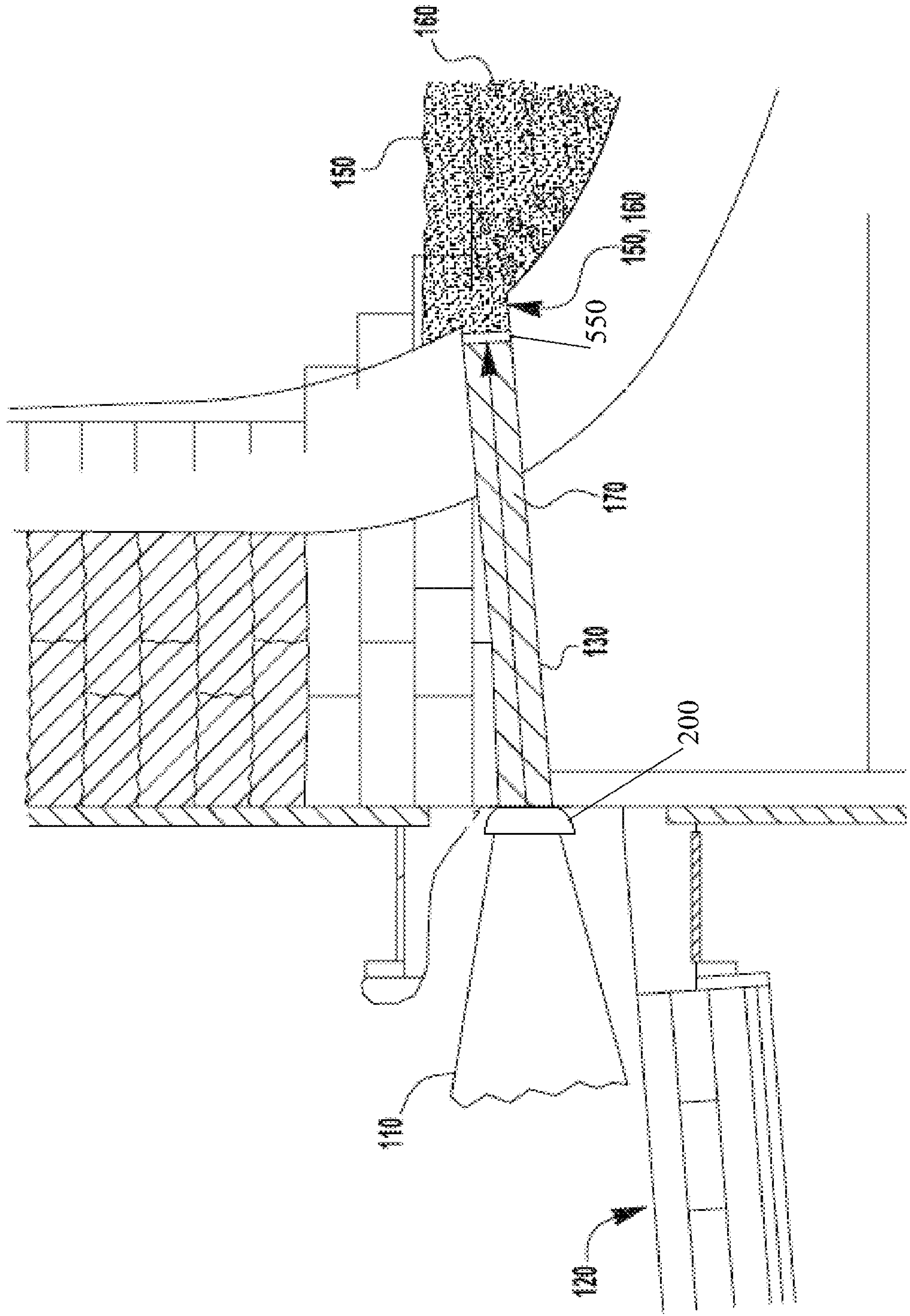


FIG. 7

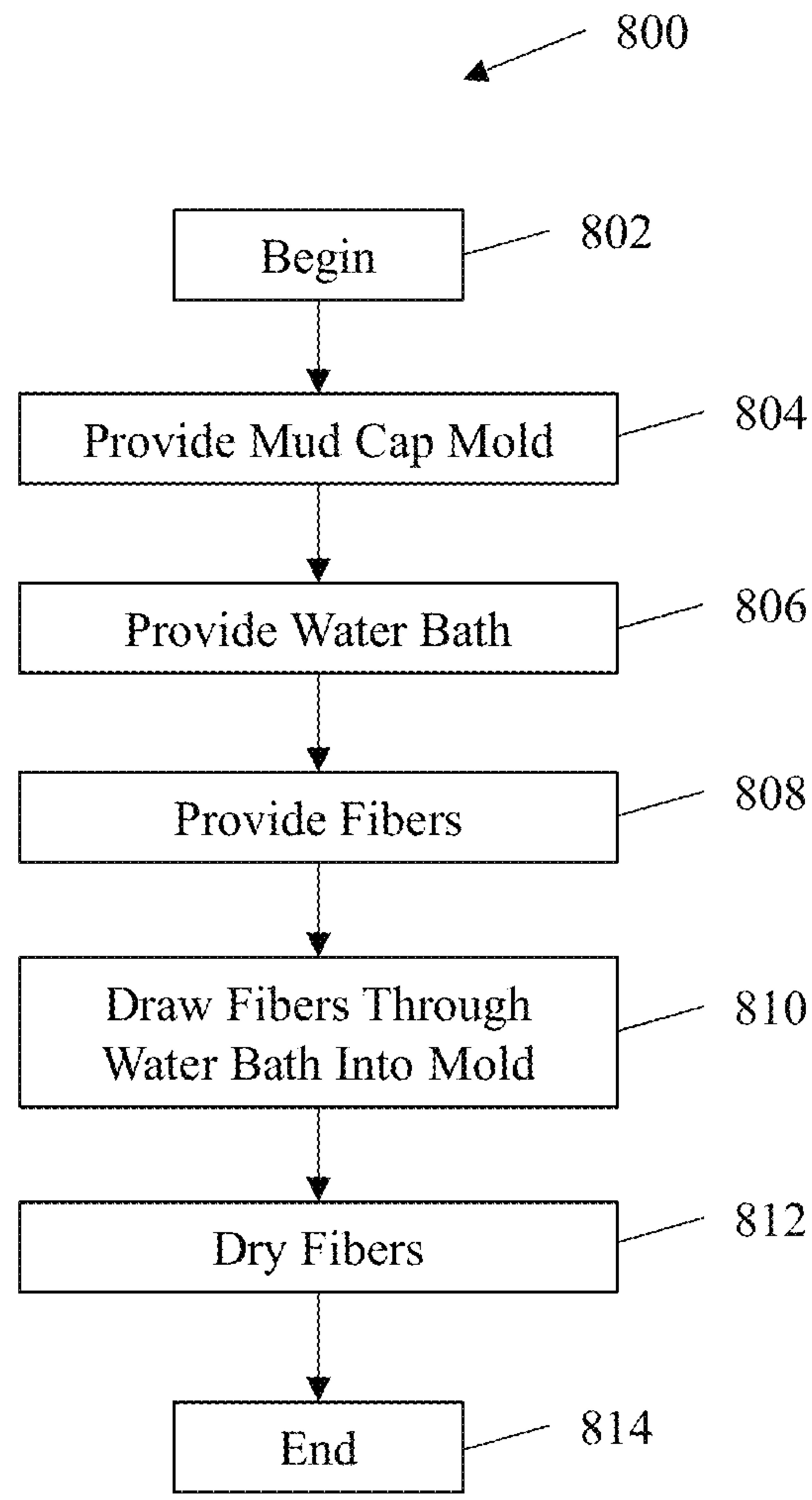

800
Begin
802
Provide Mud Cap Mold
804
Provide Water Bath
806
Provide Fibers
808
Draw Fibers Through Water Bath Into Mold
810
Dry Fibers
812
End
814

FIG. 8

MUD GUN CAP

RELATED APPLICATIONS

This application claims priority to and the benefits of U.S. Provisional Patent Application Ser. No. 62/670,288, which was filed on May 11, 2018 and which was entitled MUD GUN CAP, and which is incorporated herein by reference in its entirety.

FIELD OF USE

This invention relates generally to blast furnace iron making operations and more particularly to a mud gun cap for the nozzle of a mud gun.

BACKGROUND

Raw materials, including iron ore, limestone, and coke are added to a blast furnace where they are heated. As the raw materials are heated, molten iron forms at the bottom of the blast furnace and a layer of slag forms on top of the molten iron. After a sufficient volume of molten iron builds up at the bottom of the blast furnace, the blast furnace is tapped to remove the molten iron. A tap drill is used to tap the blast furnace by drilling out the tap hole. As the tap drill is removed, molten iron flows through the tap hole into a trough where it is routed to a waiting rail car.

After the molten iron is drained out of the blast furnace, or after a desired amount of iron has been drained from the blast furnace, the tap hole is sealed. The tap hole is sealed with a mud gun. An anhydrous mixture, commonly referred to as "mud" or "clay" is loaded into the mud gun. The mud gun rotates from a non-operating or resting position to its operating position. In its operating position the mud gun is positioned so that the nozzle **110** (FIG. **1**) of the mud gun (not shown) is aligned with the tap hole **130**. Mud **170** is extruded through the nozzle **110** and forced into the tap hole **130**. The mud **170** forces the residual molten iron **160** and slag **150** that is in the tap hole **130** back inside the furnace **140**. Inevitably, however, not all of the iron **160** and slag **150** is pushed back into the furnace **140** i.e., some of the iron **160** or slag **150** remains in the tap hole **130** and mixes with the mud **170** forming a mud and ore residue **180**. The mud gun nozzle **110** remains in place until the mud **170** dries or cures. After the mud **170** is cured, the mud gun is rotated back away from the blast furnace **140**.

The mud and ore residue **180** in the tap hole **130** cause binding and wear on the tap drill (not shown) during the subsequent tapping of the blast furnace **140**. In addition, the mud and ore residue **180** causes the drill to "walk" resulting in an irregular shaped, or oversized hole. This is undesirable because, among other things, the size of the drilled hole controls the speed of the flow of molten iron **160** out of the blast furnace.

In addition, as the nozzle **110** nears the tap hole **130**, the nozzle **110** comes into contact with the molten iron **130** and slag **150**. Overtime, the tip of the nozzle **110** deteriorates and the mud gun nozzle **110** must be replaced. The deterioration is often referred to as rat toothing, because the lower portion of the nozzle tip which routinely comes into contact with the molten iron **160** is eroded faster than the upper potion of the nozzle tip which occasionally comes into contact with the molten iron. Replacement of the mud gun nozzle **110** is expensive and time consuming.

In operation, prior to rotating the mud gun into position to plug the tap hole **130**, the operator ensures that the mud **170** is at the end of the nozzle **110**. Mud **170** at the end of the nozzle **110** prevents molten iron **160** from entering and deteriorating the interior of nozzle **110** when the mud gun is rotated into position. However, as the mud gun rotates into position, mud **170** occasionally falls out of the nozzle **110** and into the trough **120**. The mud **170** contacts the molten iron **160** and slag **150** and creates black smoke and may cause splashing of the molten iron **160**. This smoke often results in the environmental protection agency (EPA) issuing a fine to the steel manufacturer.

The novel mud gun cap disclosed herein is an improvement over Applicants prior art mud gun cap is disclosed in U.S. Pat. No. 8,083,988.

SUMMARY

Exemplary embodiments of mud gun caps are disclosed herein. An exemplary mud gun cap includes a flame-resistant body that has a tap hole contacting surface. The flame-resistant body has side wall; a first bore and a second bore located within the flame-resistant body. The first bore has a first diameter and second bore has a second diameter. The first diameter is smaller than the second diameter and the second bore is located farther away from the tap hole contacting surface than the first bore.

Exemplary methods of making a mud gun cap are also disclosed herein. An exemplary methodology of making a mud gun cap includes providing a mud gun cap mold, providing a water bath and providing flame-resistant fibers. The methodology further includes drawing the flame-resistant fibers through the water bath into the mud gun cap mold, removing the mud gun cap mold from the water bath, drying the mud gun cap, and removing the mud gun cap from the mold.

Another exemplary mud gun cap includes a flame-resistant body. The flame-resistant body has a tap hole contacting surface and has side walls extending up from the contact surface at an angle of between about 15 degrees and about 50 degrees. A first bore is located within the flame-resistant body. The first bore is sized to fit over the tip of a mud gun nozzle and the mud gun cap is a molded from flame-resistant fibers having a rating of at least about 2600° Fahrenheit.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** (Prior Art) is a cross-section of a portion of a blast furnace, a tap hole, a mud gun nozzle and a trough;

FIG. **2** is a top perspective view of an exemplar-embodiment of a mud gun cap;

FIG. **3** is a top view of the mud gun cap of FIG. **2**;

FIG. **4** is a side view of the mud gun cap of FIG. **2**;

FIGS. **5**A and **5**B are a cross-sections of the mud gun cap secured to two different mud gun nozzles;

FIG. **6** is a cross-sectional view of a portion of a blast furnace, mud gun nozzle and a mud gun cap with mud injected into the tap hole and a portion of the mud gun cap progressing through the tap hole;

FIG. **7** is also a cross sectional view of a portion of the blast furnace, the mud gun nozzle and the mud gun cap with the mud fully injected and the portion of the mud gun cap near the end of the tap hole; and

FIG. **8** is an exemplary methodology for producing a mud gun cap.

DETAILED DESCRIPTION

FIG. **2** and is a perspective view of an embodiment of a mud gun cap **200**. FIG. **3** is a plan view of mud gun cap **200** and FIG. **4** is a side elevational view of mud gun cap **200**. In some embodiments, the mud gun cap **200** is made of a flame-resistant fiber material, such as, for example, a 2600 or 2800 degree Fahrenheit fiber. In some embodiments, the fiber is a ceramic fiber.

Mud gun cap **200** is preferably a single molded unit made up of the flame-resistant fiber material. Mud gun cap **200** includes side wall **201**. Side wall **201** is configured to enclose the end portion of the mud gun nozzle **110**. In some embodiments, the side walls extend up and outward from the end surface at an angle of between about 15 and 65 degrees. In some embodiments, the side walls extend up and outward from the end surface at an angle of between about 20 and 50 degrees. In some embodiments, the side wall extends up and outward from the end surface at an angle of between about 25 and 45 degrees. The flame-resistant material surrounding the end portion of the mud gun nozzle **110** protects the tip of the mud gun nozzle **110**. The side wall increases safety because it diffuses the iron flow and limits the splashing of iron when the mud gun nozzle **110** is rotated in position and placed in the flow path of the molten iron. In addition, the inventive mud gun cap **200** helps protect the integrity of the tap hole.

The interior of mud gun cap **200** includes a bottom surface **208**, a first bore **206** and a second bore **204**. The diameter D**1** of first bore **206** is smaller than the diameter D**2** of second bore **204**. Located at the bottom of second bore is a shelf **205**.

In some embodiments, the tip of mud gun nozzle **500**A has an outside diameter of N (see FIG. **5**A). The first bore of mud gun cap **200** has a diameter D**1** that is slightly larger than the outside diameter N mud gun nozzle **500**A and fits snuggly over the tip of mud gun nozzle **500**A as shown in FIG. **5**A. In some embodiments, the tip mud gun nozzle **500**B has an outside diameter of M**1**, which is slightly smaller than the diameter D**2** of second bore **204**. Accordingly, second bore **204** fits snuggly over the tip of mud gun nozzle **500**B. The inside diameter M**2** of the tip of mud gun nozzle **500**B is about the same size as the diameter D**1** of first bore **206**. Mud gun cap **200** includes a portion **550** on surface **551**. As described below, in some embodiments, portion **550** is configured to break off of mud cap **200** and move up into the tap hole (not shown) due to the movement of the mud **170**. In some embodiments, portion **550** is outline by perforations (not shown) allowing the portion **550** to more cleanly separate from mud gun cap **200**. In some embodiments, portion **550** breaks to allow mud **170** to flow up into the tap hole. In some embodiments, perforations (not shown) control the breakage of portion **550**. IN some embodiments, the perforations extend from the center of portion **550** outward.

FIGS. **7** and **8** illustrate operation of a mud gun (not shown) having a mud gun cap **200** on the mud gun nozzle **110**. The mud gun is rotated into position to plug the tap hole **130** of the blast furnace **140**. As the mud gun is rotated into position, the outer face **551** of mud gun cap **200** comes into contact with the molten iron **160** flowing out of the tap hole **130**. The outer face **551** and sides **201**, which may be 2800 degree Fahrenheit fiber, protect the tip of the mud gun nozzle **110**. As a result, use of the mud gun cap **200** extends the life of the mud gun nozzle **110** because the molten iron **160** does not come in contact with the mud gun nozzle **110** and cause deterioration. In addition, the mud gun cap **200** deflects the flow of molten iron **160** and limits splashing of the molten iron **160** as the mud gun nozzle **110** is rotated in place.

When the mud gun is rotated into position, the outer face **551** is pressed firmly against the tap hole **130**. The mud gun is activated and forces mud **170** through the nozzle **110**. The pressure exerted by the mud **170** causes the portion **550** to break or shear off allowing the mud **170** and, in some embodiments, the sheared off portion **550**, to be forced up into the tap hole **130**. In some embodiments, portion **550** fractures and remain secured to mud cap **200**. Treatments, such as, for example, perforations, may be used to control the locations of the fractures so that the size and shape of the fractured portions of outer surface **551** are relatively predictable and whether or not the fragments of portion **550** remain attached to mud gun cap **200** or travel up the tap **130** along with the mud **170** is also predictable.

As the portion **550** is forced up through the tap hole **130** it acts as a barrier between the slag/molten iron **150**/**160** and the mud **170**. In FIG. **7** the portion **550** is shown about half way up the tap hole **130**. In FIG. **8** the tap hole **130** is filled with mud **170** and the portion **550** is shown near the end of the tap hole **130**. In some embodiments, portion **550** at least partially prevents slag/molten iron **150**/**160** from remaining in the tap hole **130** and mixing with the mud **170** to form a mud and ore residue **180** (illustrated in FIG. **1**). After the mud **170** dries or cures, the mud gun is rotated back into its resting position. The mud gun cap **200** either falls off on its own, or is knocked off by an operator.

In addition, since the tap hole **130** is now filled with mud **170** and contains less mud and ore residue **180**, the tap hole drill (not shown) has an easier time drilling a clean hole in the tap hole **130** during subsequent tapping operations. This extends the life of the tap drill bit and allows for more precise control over the molten iron **160** flow rate.

FIG. **8** is an exemplary methodology **800** for making a mud gun cap. The exemplary methodology is by way of example only and is not meant to be limiting. In some embodiments, additional steps are performed. In some embodiments, not all of the steps are performed. In addition, the blocks need not be performed in the order shown and described and may be performed in different orders with additional steps or with fewer steps.

The exemplary methodology **800** begins at block **802** and at block **804** a mud gun cap mold is provided. A water bath is provided at block **806** and flame-resistant fibers are provided at block **808**. At block **810** the flame-resistant fibers are drawn through the water bath into the mud gun cap mold. The mold is removed from the water bath and dried at block **812** and the methodology ends at block **814**.

While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. For example, the outer face **210** may be perforated around the inside edge of the ring **220** allowing a cleaner tear as the mud **170** is forced through. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

I claim:

1. A mud gun cap comprising:

a flame-resistant body having fibers with a flame rating of at least 2600 degrees;

the flame-resistant body having a tap hole contacting surface;

the flame-resistant body having side walls;

a first bore located within the flame-resistant body;

a second bore located within the flame-resistant body;

the first bore having a first diameter and second bore having a second diameter, wherein the first diameter is smaller than the second diameter;

wherein the second bore is located farther away from the tap hole contacting surface than the first bore;

wherein the tap hole contacting surface contains one or more perforations to control braking of the surface.

2. The mud gun cap of claim **1** wherein the side walls are angled outward from the tap hole contacting surface.

3. The mud gun cap of claim **2** wherein the side walls are angled from between about 10 degrees to about 60 degrees.

4. The mud gun cap of claim **2** wherein the side walls are angled from between about 20 degrees to about 45 degrees.

5. The mud gun cap of claim **1** wherein the mud gun cap comprises at least a 2600 degree Fahrenheit fiber.

6. The mud gun cap of claim **1** wherein the fibers comprise a ceramic fiber.

7. A method of making a mud gun cap comprising:

providing a mud gun cap mold;

providing a water bath;

providing flame-resistant fibers;

drawing the flame-resistant fibers through the water bath into the mud gun cap mold;

removing the mud gun cap mold from the water bath;

drying the mud gun cap;

removing the mud gun cap from the mold and

adding one or more perforations to a tap hole surface to control breaking of the tap hole surface.

8. A mud gun cap comprising:

a flame-resistant body;

the flame-resistant body having a tap hole contacting surface;

the flame-resistant body having side walls extending up from the contact surface at an angle of between about 15 degrees and about 50 degrees;

a first bore located within the flame-resistant body;

the first bore sized to fit over the tip of a mud gun nozzle;

Wherein the mud gun cap is a molded from flame-resistant fibers having a rating of at least about 2600° Fahrenheit;

wherein the tap hole contacting surface contains one or more perforations to control braking of the surface.

9. The mud gun cap of claim **8** further comprising a second bore located within the flame-resistant body;

the first bore having a first diameter and second bore having a second diameter, wherein the first diameter is smaller than the second diameter; and

wherein the second bore is located farther away from the tap hole contacting surface than the first bore.

10. The mud gun cap of claim **8** wherein the side walls are angled outward from the tap hole contacting surface from between about 20 degrees to about 45 degrees.

11. The mud gun cap of claim **8** wherein the flame-resistant fibers are ceramic fibers.

* * * * *